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Title: Observer Bias and Variance of Prostate Size Estimates with Computed Tomography Decrease in Larger Prostates

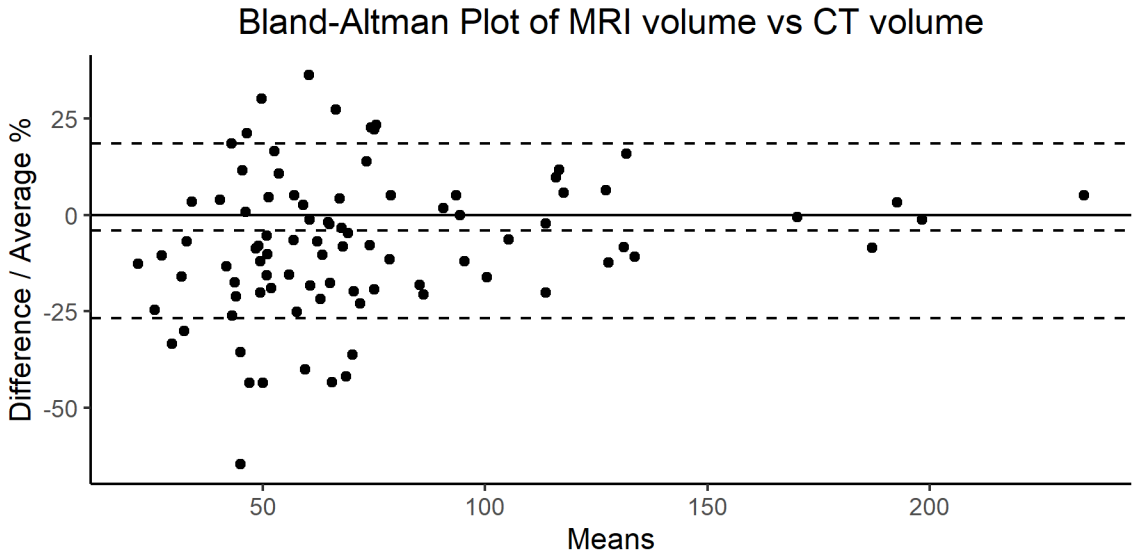
Introduction and Objective: Since the start of the COVID-19 pandemic, we have seen a rise in the use of telemedicine and a decrease in the use of office procedures, such as transrectal ultrasound (TRUS), for the calculation of prostate volume. Given that yearly prostate growth is minimal in benign prostatic hyperplasia (BPH), there has been increasing reliance on previously obtained imaging for calculation of prostate volume. Several studies report close correlation between magnetic resonance imaging (MRI), TRUS, and specimen weight after radical prostatectomy. Other studies report that computed tomography (CT) overestimates volumes on small prostates and underestimates volumes on large prostates, although these have been limited to prostate sizes less than 60 grams in the radiation oncology literature. We evaluated the observer bias and variance of prostate size estimates using CT for different prostate sizes to determine if CT is comparable to MRI.

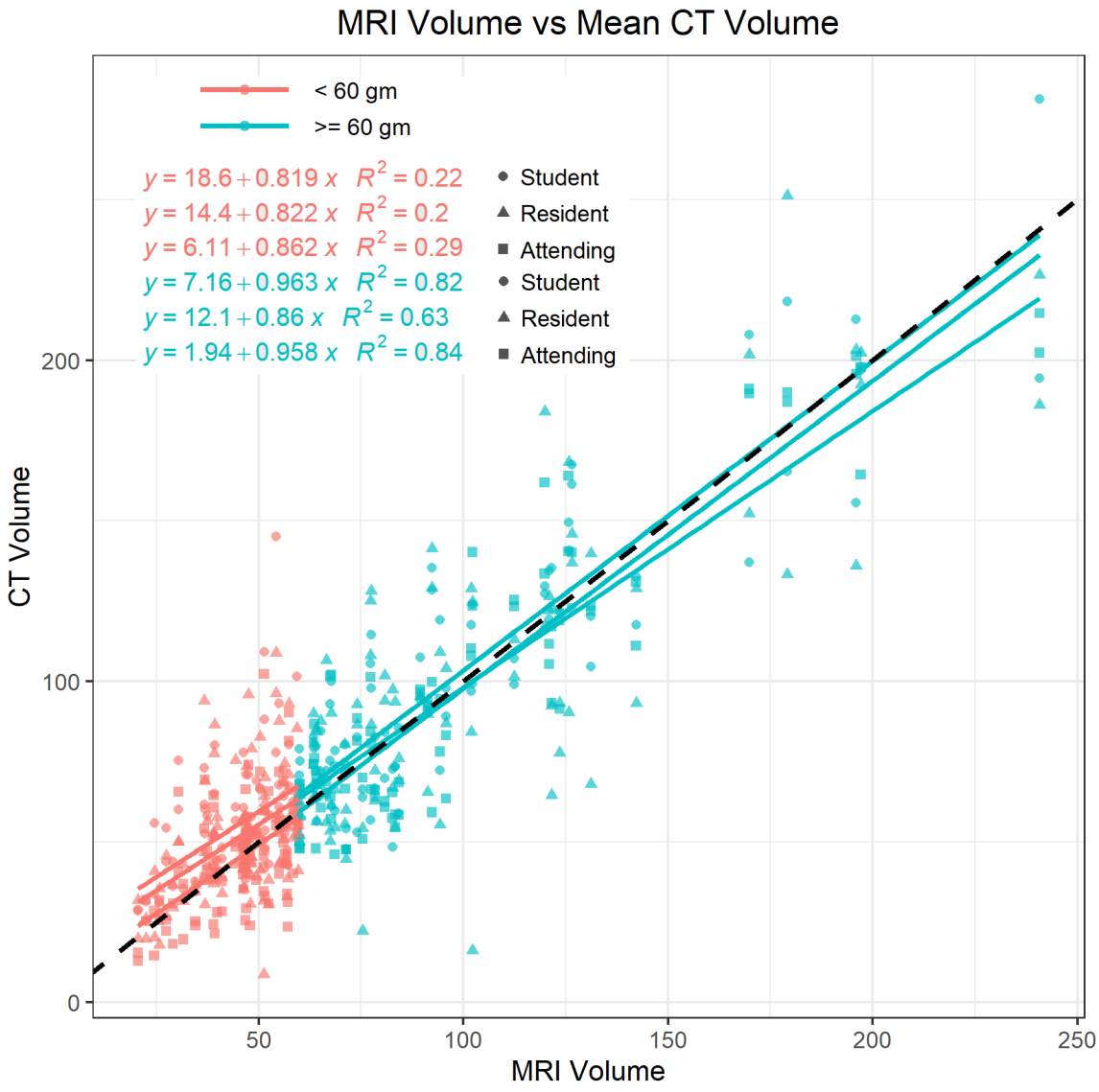
Methods: We retrospectively reviewed 700+ men with BPH who had undergone MRI fusion biopsy at our institution. We included men who had CT scans, with or without contrast, within two years of their MRI. We excluded men with indwelling catheters, history of transurethral or prostate intervention, and extracapsular extension on MRI. Six individuals reviewed CT scans of 89 men three times and calculated prostate size using the prolate ellipsoid formula. Reviewers represented different training levels – two medical students, urology residents, and urology attending physicians. Prostate sizes by MRI were estimated by a radiologist. The median prostate size was 59.7 grams, so the groups above and below 60 grams were compared. In order to assess agreement of CT with MRI estimation of prostate volume, we used a Bland-Altman analysis. To assess variance of prostate size estimates with CT, we calculated Pearson correlation coefficients in the two size groups and for each reviewer class. Statistical analysis was done using RStudio and Vassarstats.com.

Results: Mean age was significantly higher in the ≥60gm than the <60gm group (69.5 vs 65, p=0.004). Race, BMI, and presence of prostate cancer were not significantly different. Figure 1A shows a decrease in observer bias between CT and MRI volumes as prostate size increases ≥60gm. Figure 1B shows the degree of inter-rater variance between CT and MRI volumes in the two size groups. Pearson correlation coefficients were in the 0.2-0.3 range in the <60gm group and 0.6-0.8 in the ≥60gm group.

Conclusions: Based on our analysis, CT appears to accurately estimate prostate size as measured by MRI in prostates that are ≥60gm and overestimates prostate size in prostates that are <60gm. This could be due to measurement of peri-prostatic tissues such as the Denonvilliers' fascia and neurovascular bundle, which are less clearly defined around smaller glands. We have seen increasing use of previous cross-sectional imaging to estimate prostate size since the start of the COVID-19 pandemic and these findings support the use of CT to estimate prostate size in larger glands, but we would use caution when doing so in smaller glands.

	< 60 gm (N=45)	≥ 60 gm (N=44)	Overall (N=89)	P Value
age				
Mean (SD)	64.0 (12.4)	69.5 (5.72)	66.7 (10.0)	0.004
Median [Min, Max]	65.0 [0, 83.0]	70.0 [55.0, 79.0]	68.0 [0, 83.0]	
race				
White	36 (80.0%)	32 (72.7%)	68 (76.4%)	0.646
Black	3 (6.7%)	8 (18.2%)	11 (12.4%)	0.107
Other	6 (13.3%)	4 (9.1%)	10 (11.2%)	0.554
BMI				
Mean (SD)	29.9 (3.69)	29.9 (4.92)	29.9 (4.32)	0.499
Median [Min, Max]	30.0 [22.5, 40.9]	30.3 [17.5, 40.9]	30.0 [17.5, 40.9]	
prostate_cancer				
No	20 (44.4%)	28 (63.6%)	48 (53.9%)	0.129
Yes	25 (55.6%)	16 (36.4%)	41 (46.1%)	0.321
MRI_vol				
Mean (SD)	44.5 (10.8)	100 (42.3)	71.9 (41.4)	<0.0001
Median [Min, Max]	46.8 [20.5, 59.7]	83.8 [60.0, 241]	59.7 [20.5, 241]	
mean_CT_vol				
Mean (SD)	51.5 (14.0)	101 (42.3)	76.0 (39.9)	<0.0001
Median [Min, Max]	50.9 [23.3, 83.2]	90.4 [49.4, 229]	65.8 [23.3, 229]	
delay_CT_MRI				
Mean (SD)	16.4 (262)	46.5 (259)	31.3 (260)	0.294
Median [Min, Max]	35.0 [-523, 618]	52.0 [-667, 578]	39.0 [-667, 618]	
prostate_med				
No	42 (93.3%)	36 (81.8%)	78 (87.6%)	0.544
Yes	2 (4.4%)	8 (18.2%)	10 (11.2%)	0.289
Missing	1 (2.2%)	0 (0%)	1 (1.1%)	
prostate_med_type				
none	43 (95.6%)	36 (81.8%)	79 (88.8%)	
finasteride before both images	2 (4.4%)	6 (13.6%)	8 (9.0%)	
finasteride started btwn images	0 (0%)	1 (2.3%)	1 (1.1%)	
lupron started before images	0 (0%)	1 (2.3%)	1 (1.1%)	
lupron started btwn images	0 (0%)	0 (0%)	0 (0%)	


Bland-Altman Plot of MRI volume vs CT volume
Difference / Average %
25
0
-25
-50
50
100
150
200
Means


MRI Volume vs Mean CT Volume
< 60 gm
>= 60 gm
y = 18.6 + 0.819 x R2 = 0.22
y = 14.4 + 0.822 x R2 = 0.2
y = 6.11 + 0.862 x R2 = 0.29
y = 7.16 + 0.963 x R2 = 0.82
y = 12.1 + 0.86 x R2 = 0.63
y = 1.94 + 0.958 x R2 = 0.84
Student
Resident
Attending
Student
Resident
Attending
CT Volume
0
100
200
50
100
150
200
250
MRI Volume